ABSTRACTS FROM ASTRONOMICAL PUBLICATIONS.

In accordance with a recent arrangement the members of the scientific staff of the Lick Observatory hold meetings once per week, as an observatory duty, to report upon and discuss the more important articles appearing in the journals of astronomy, the important new books on astronomical subjects, or subjects of current and special interest in the observatory's work. It has been suggested that abstracts of the reports would be of interest to the readers of these Publications, and the Publication Committee has acted favorably upon the suggestions.

It is intended to preserve the qualities of abstracts as far as possible, and to restrict published criticisms, favorable or unfavorable, to a minimum.

RESEARCHES ON THE MOTION OF THE MOON, BY SIMON NEWCOMB.[1]

This work, which has recently been distributed, contains the final memoir prepared by the late Professor NEWCOMB, the copy for the printer having been completed only a month before his death. It is a continuation of the author's former memoir on the Moon's motion, which was published as an appendix to the Washington observations for 1875. In the preface to the present volume it is stated that "the whole work may be described as a discussion of ancient and mediæval eclipses of the Sun and Moon, and of occultations of stars by the Moon observed from 1627 to the present time, with the general purpose of studying those fluctuations in the Moon's motion which are not represented by existing theory."

"The most important fact," NEWCOMB says, "brought out by this and other researches of the author on this subject, and by a comparison with the theoretical researches of other investigators, especially of Professor ERNEST W. BROWN, is that the Moon's mean motion is subject to fluctuations which are not only unrepresented by existing theory, but for which it seems difficult to assign any sufficient physical cause."

The main purpose of the present memoir is "to show with all the precision of which the observations admit, what unexplained fluctuations the mean motion of the Moon has actually undergone." The observations are, principally, those of occultations of stars by the Moon, and the method of investigation is, in brief, the comparison of the Moon's positions as deduced from

[1] Volume IX, Part I, of the "Astronomical Papers," prepared for the use of the *American Ephemeris and Nautical Almanac.*

these observations, with those derived from HANSEN'S tables, after the latter have been corrected to reduce them to the "provisionally accepted theory." This comparison gives the data from which equations of condition are formed, whose solution gives the deviations from theory of the Moon's mean motion in longitude. The account of the methods and formulæ of reduction adopted, of the corrections to HANSEN'S tables, and of the data relating to the original observations is followed by chapters giving the corrected tabular positions of the Moon, the positions of the occulted stars, the position-angles used in computing the coefficients of the equations of condition, and these equations in full. The final chapters are then given to a discussion of the results obtained from the solution of the equations combined with the results from the author's earlier investigations.

The principal conclusion reached is that "there is no value which we can assign to the Moon's undisturbed mean motion as definitive." There are fluctuations which cannot as yet be explained. "So long as they might be supposed to arise from defects in the computations of gravitational theory we might plausibly suppose them to arise from actual periodic terms which had eluded our scrutiny. But today it seems almost as certain as any proposition in mathematical science can be that there are no known masses of matter, the gravitational action of which could produce the observed effects. Working quite independently of each other, I feel that BROWN and I have examined every possible term and made such estimation of its limiting possible magnitude as to insure the correctness of our conclusions. BROWN has gone yet further by finding the limiting value of any possible omitted term to be insensible."

The expression for the great fluctuation is given by NEWCOMB as,—

$$\delta v = 12''.95 \sin\left[1^\circ.31\ (t - 1800.0) + 100^\circ.6\right]$$

Period = 275 years.

Superimposed upon this are smaller fluctuations.

The author closes his "concluding remarks" with these sentences: "The most unsatisfactory feature of the conclusion of the entire work as carried through by the author is that, until

the matter is cleared up, it will be impossible to predict the Moon's mean longitude with the precision required for astronomical purposes. We shall be obliged to correct the Moon's mean longitude from time to time, perhaps at intervals of 10 or 20 years, from observations."

Dr. FRANK E. ROSS was Professor NEWCOMB's associate in carrying out this investigation, acting both as computor and as superintendent of computations. R. G. AITKEN.

May, 1913.

THE MASS OF THE NUCLEUS OF HALLEY'S COMET.

In a paper published in the *Bulletin of the St. Petersburg Academy,* 1913, No. 5, Professor S. ORLOFF gives an interesting investigation of this question, based upon photometric observations. Just as we have a phase effect in the light from the Moon, so also if the nucleus of a comet consists either of a single mass or of a swarm of small material particles, it should show a phase effect depending upon its position with reference to the Sun and to the observer. Earlier investigations by the same author have shown the existence of a phase effect in the nucleus of Halley's Comet, and in the present paper ORLOFF makes the attempt to separate from all the light proceeding from the nucleus that portion which may be due solely to the reflected rays of the Sun, depending upon the phase angle and upon the distances of the comet from the Earth and the Sun respectively (Δ and r).

Besides this reflected light, the nucleus may give out intrinsic light of its own, as a secondary effect of the action of the solar rays.

For the reflected rays the law of diminution of brightness is—

$$\frac{X}{a\Delta^2 r^2},$$

where a is the correction for phase; for the calculation of this factor ORLOFF used tables derived according to LAMBERT's theory. For the diminution of the intrinsic light of the nucleus, the law is, of course, unknown, but may be expressed by the formula,—

$$\frac{Y}{\Delta^2 r^n},$$

where the exponent n is unknown, and must be so determined as best to satisfy the observations. The observed brightness of the nucleus H_1 may then be represented as the sum of the reflected and the intrinsic light in the form,—

$$\frac{X}{a\Delta^2 r^2} + \frac{Y}{\Delta^2 r^n} = H_1.$$

Each individual observation gives, accordingly, one equation with the three unknowns, X, Y and n, to be solved by least squares. Before the passage of Halley's Comet through perihelion the influence of phase was negligible, amounting to only 0.18 magnitude; thirty observations by BEMPORAD were selected for the investigation, taken in the epoch from May 24 to July 4, 1910, after the passage of the comet across the Sun's disk. The solution gave,—

$$X = 5.717 \text{ and } Y = 0.072.$$

An inspection of the relative magnitude of these quantities shows at once that the nucleus shone only by reflected light, the amount of intrinsic light being negligible. Another solution showed that it was impossible to neglect the effect of phase.

The investigation showing that the nucleus shone simply by reflected sunlight like a star of magnitude 7.2, it becomes possible to compute the mass of the nucleus; here three assumptions are necessary:—

1. Concerning the magnitude of the nuclear particles;
2. Concerning the albedo of these granules;
3. Concerning their density.

For the albedo ORLOFF takes 0.2 (*Mars* = 0.22), and for the density of the particles he takes the mean density of the Earth. If the nucleus were one solid mass, a maximum value of the mass is obtained; postulating, on the other hand, that it is made up of small particles of not less than 2^{mm} radius, a minimum value is obtained (if particles were smaller than this, the influence of light pressure would be greater than 0.0001 of gravitation, and marked perturbative effects would be noticed in the orbit of the comet). It is possible to affirm with some certainty that the mass of the nucleus is included between the

two limits thus given. ORLOFF'S results are (Earth's mass $= 1$):—

$$\frac{1}{2 \cdot 10^{14}} < \text{mass of nucleus} < \frac{1}{6 \cdot 10^{5}}$$

Either value is probable and possible, but everything leads to the belief that the smaller value is more likely to be nearer the truth, and it is not improbable that the true mass of the nucleus of Halley's Comet may be much less even than this. This minimum mass amounts to about thirty million tons, equal to less than six cubic miles of air at sea level density.

H. D. CURTIS.

THE ORBIT OF β CORONÆ BOREALIS ($15^h\,23^m.7$).[1]

An unusual circumstance attends the determination of the orbit of β *Coronæ Borealis,* which has been observed during 1910-1912 at the Dominion Observatory in Ottawa, Canada. The star's spectrum is given in the *Annals* of Harvard College Observatory as "F peculiar," with the note that "this star is very peculiar in the relative intensity of the solar lines." Mr. J. B. CANNON, who measured the plates and determined the orbit, says that the lines are so different from those of a solar standard plate that the comparator measures were very unreliable. Consequently all plates were measured with respect to a single plate of the star itself and the latter plate was given the best measurement possible on the comparator against the solar standard. A consecutive plot of observations gave evidence of an oscillating amplitude of velocity. The period of this oscillation is 490.8 days, while the period of the simple velocity oscillation is 40.9 days. The range of the variation of amplitude is $4^{km}.8$. A sine curve was assumed for the long oscillation and the values given by it applied to the velocities obtained from the different plates in order to get a curve for the short period and to use all the observations in the determination of this curve. Fourteen normal places were formed and the elements were derived by the graphical methods only, since the accuracy of the measures was not sufficient for further reduction. The eccentricity 0.4 is quite large. The sine curve of the short

[1] *Journal of the Royal Astronomical Society of Canada,* **6,** 343, 1912.

period cannot be considered well defined. The amplitude is $6^{km}.2$, which is not much greater than that of the long period. The probable error of an average observation is $2^{km}.6$, which is greater than the semi-amplitude of the long period. The probability of the variation of amplitude would seem to depend upon its apparent periodicity and the reduction of residuals to reasonable size.

G. F. PADDOCK.

THE DETERMINATION OF THE CLASS OF THE SECONDARY SPECTRA OF ALGOL VARIABLES.

In Dr. SCHLESINGER'S discussion of spectroscopic binaries,[1] he says there was at that time no definite evidence of a difference of spectrum between the primary and secondary components of first-type stars. But, of course, at that time few secondary spectra had been observed. Moreover, if the difference of magnitude exceeds a magnitude, the secondary spectrum is usually invisible. It has recently been found by Mr. HARLOW SHAPLEY[2] that several *Algol* variables, which would undoubtedly be shown to be spectroscopic binaries if spectrographs were able to secure the spectra of such faint stars, have considerable difference of spectrum between their primary and secondary components. His method depends upon certain facts which he has derived from the study of *Algol* systems. The radius of the secondary is in general greater than that of the primary. Since the majority of systems have nearly equal masses, the greater volumes of the secondary components indicate low densities. Assuming equal masses in thirty-five systems whose primaries have spectra of classes B and A, the average density of the primary components is one seventh (or less) that of the Sun; that of twenty-nine secondary components whose spectra are to be determined is less than one thirtieth that of the Sun. In consequence of the larger size of the secondary, many systems present total eclipse of the primary during minimum phase. The light is then entirely that of the secondary. If the latter were bright enough and the observation long enough the spectrum of the secondary could be directly obtained. But the duration of eclipse is too short except in a

[1] *Allegheny Publications*, **I**, 142.
[2] *Astrophysical Journal*, **37**, 154.

few cases. However, the color index, which is the difference between the visual and photographic magnitudes, may be found by determining the photographic and visual magnitudes at minimum brightness, or by determining the photographic and visual range of brightness. SHAPLEY thus determines the color index at minimum for two systems whose primaries are of Class A: for Y *Piscium* 0.35 magnitudes, which, according to KING'S[1] scale of color-indices and spectral class, puts the secondary in the spectral Class F0; for RR *Draconis* 0.84 magnitude, which puts the secondary in the spectral Class G4. Among spectroscopic binaries, the fainter component is the less massive. This fact and the fact of extremely low density would seem to indicate less age for the secondary than for the primary. But the later class of the secondary spectrum as found for the *Algol* variables above mentioned would seem to indicate greater age. The determination of secondary spectra is consequently important in the study of the development of close binary systems. G. F. PADDOCK.

THE RANGES OF VELOCITY AND BRIGHTNESS OF CEPHEID VARIABLES.

A significant point concerning *Cepheid* variables has recently been brought to notice by LUDENDORFF of Potsdam, who has published a note in the *Astronomische Nachrichten*[2] giving the list of known *Cepheid* variables and pointing out an apparent connection between the ranges of magnitude and of radial velocity variation. δ *Cephei* has the maxima of ranges, 0.88 in magnitude and 40^{km} in velocity. *Polaris* has the minima of ranges, 0.12 in magnitude and 6^{km} in velocity. The others increase from about a half to a whole magnitude and from 15^{km} to 50^{km}. The relation is roughly linear, expressed by the equation $2K = 47.3A$, in which K is the semi-amplitude of the radial velocity curve and A the range of magnitude. To a variation of one magnitude corresponds a range of radial velocity of about 47^{km}. A plot shows the observations to fall

[1] *Harvard Annals*, **59**, 180.
[2] *Astronomische Nachrichten*, **193**, 302.

more or less along a straight line through the origin inclined about 30° to the axis of magnitudes.

LUDENDORFF'S conclusion is that the relation is not definitely proved, but that if proved in the future, it will be possible to compute the spectroscopic orbit from the light curve; and also that one can scarcely avoid the impression that the spectral line shifts are due to some other cause than radial velocity.

The latter part of this conclusion, however, may be quite unnecessary; for, if the above relation between amplitude of oscillation and range of magnitude actually exists, it may be a function of the inclination of the orbit plane. It is well known that the greatest brightness of *Cepheid* variables occurs during the interval in which the body is supposed to be approaching the Sun. If the increase of brightness is due to a greater amount of light emitted by the advancing hemisphere, then the amount of variation of brightness visible from the solar system depends upon the inclination of the orbit plane to the line of sight. The variation of both magnitude and radial velocity would be zero if the orbit plane is perpendicular to the line of sight and greatest if the orbit plane passes through the line of sight. If, then, DUNCAN'S theory[1] be true, the relation just discovered is really a relation between the range of magnitude and the inclination of the orbit plane, so that the latter may perhaps be determinable from the former.

G. F. PADDOCK.

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[1] *Lick Observatory Bulletin*, V. 87.